Where to Go from Here

Taking Stock: Where Are We?

Goals for this Course

- ***Learn how to model and solve complex problems with computers.***
- To that end:
  - Explore common abstractions for representing problems.
  - Harness recursion and understand how to think about problems recursively.
  - Quantitatively analyze different approaches for solving problems.

What We've Covered

Strings

Streams

Recursive Problem-Solving

Stacks

Queues

Vectors

Maps

Sets

Lexicons

What We've Covered

Recursive Graphics

Recursive Enumeration

Recursive Backtracking

Big-O Notation

Sorting Algorithms

Class Design

Pointers and Memory

Constructors and Destructors

What We've Covered

Dynamic Arrays

Chained Hashing

Linear Probing

Robin Hood Hashing

Linked Lists

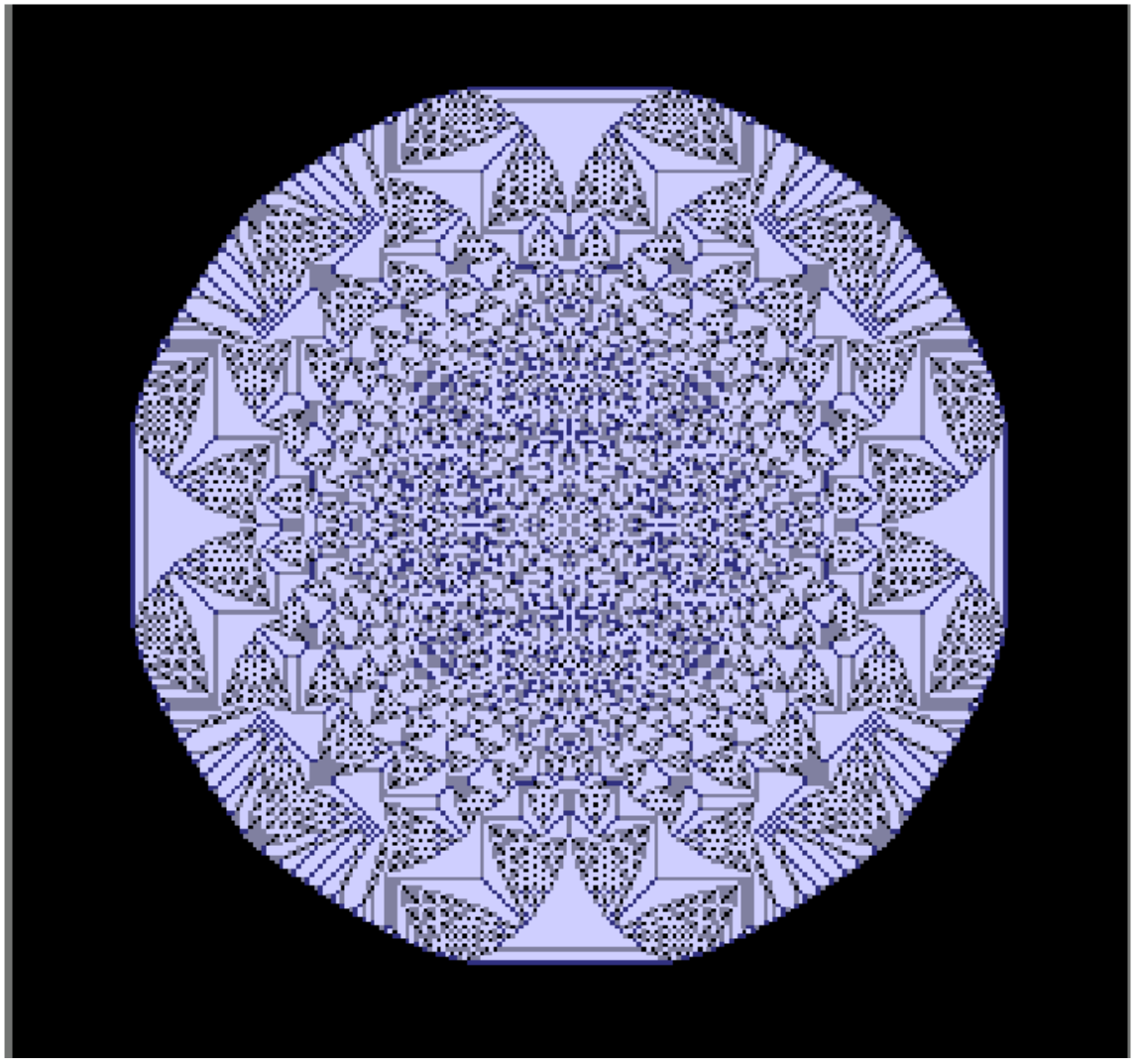
Binary Search Trees

Huffman Coding

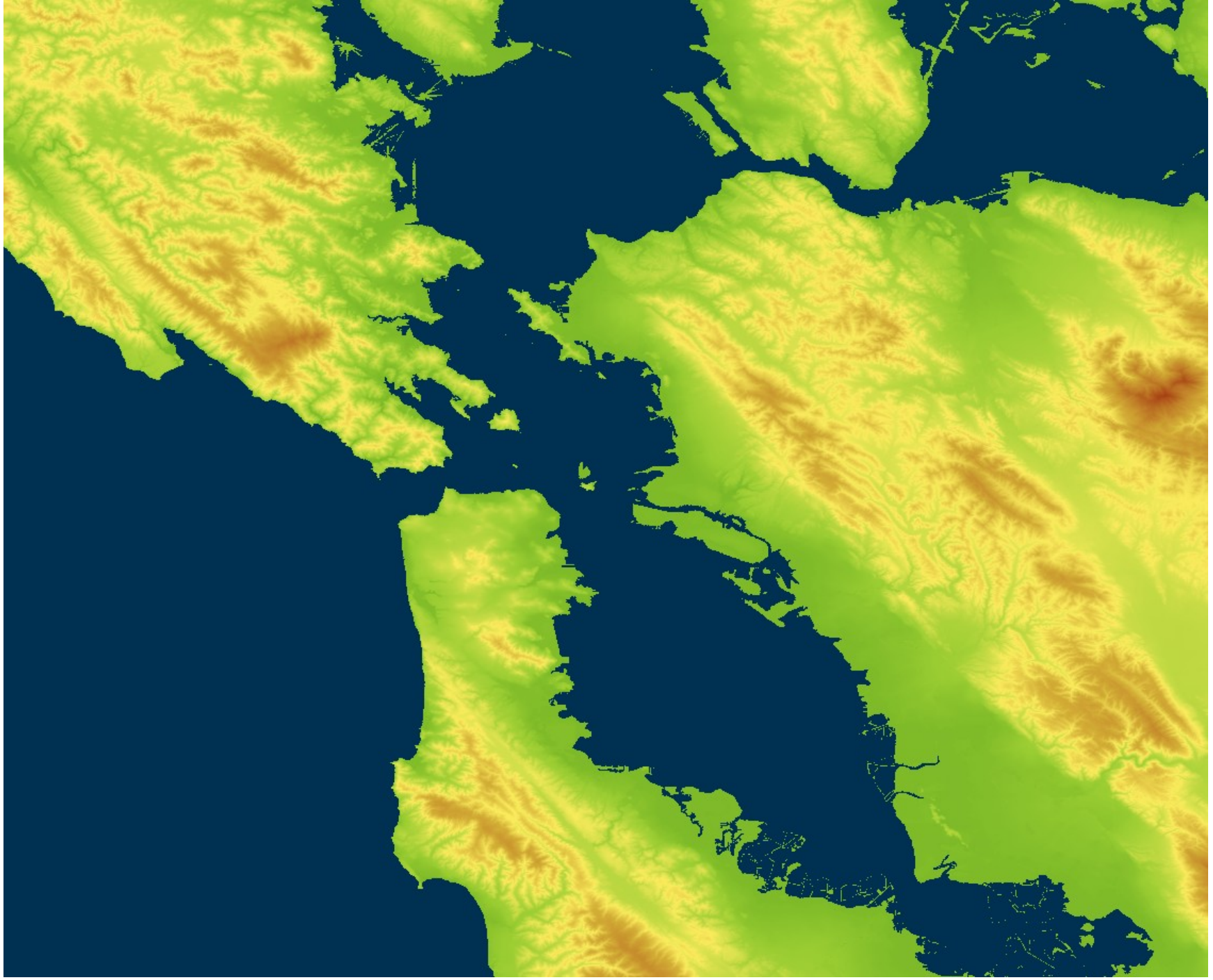
Graphs

You didn’t just learn a list of concepts.

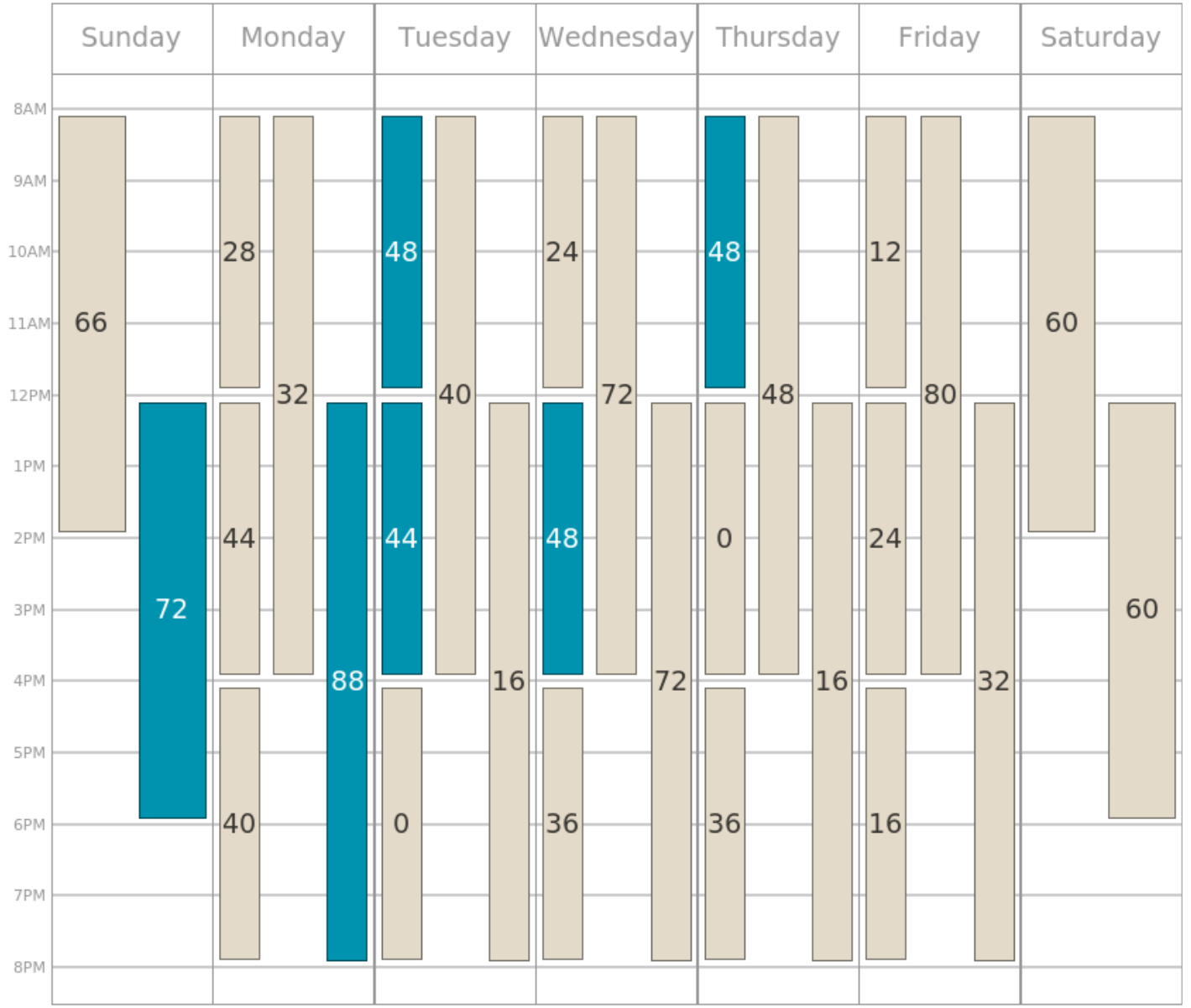
You learned to make those concepts ***shine***.



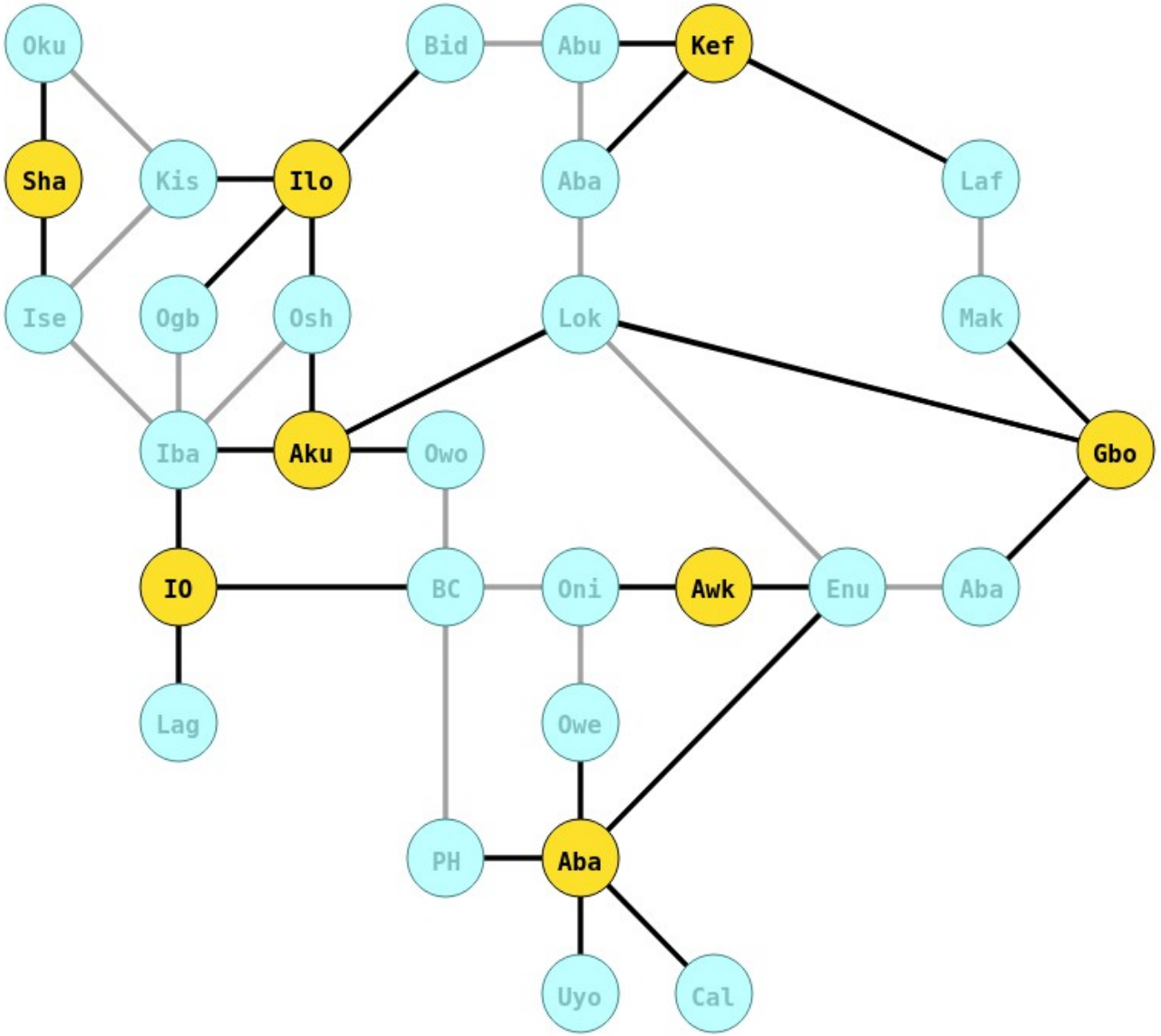
Assignment 1: Strings, Streams, and Recursion



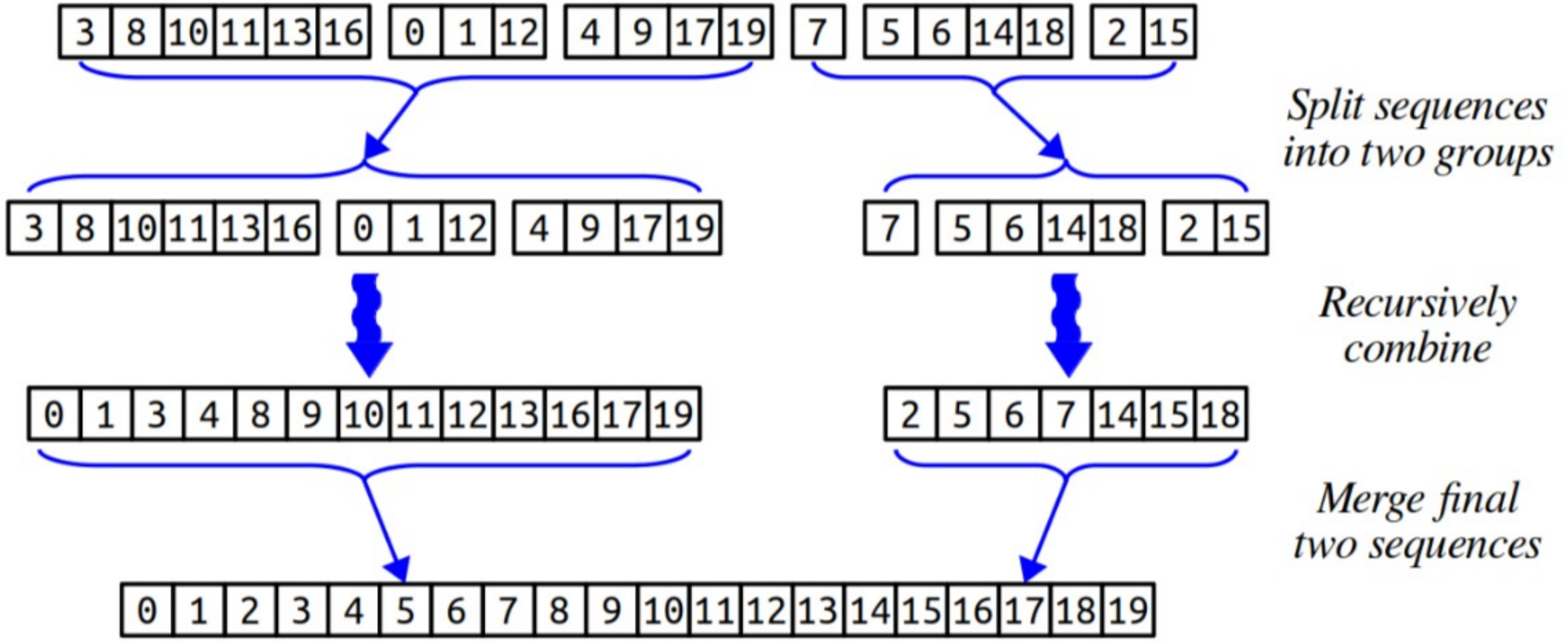
Assignment 2: Container Types



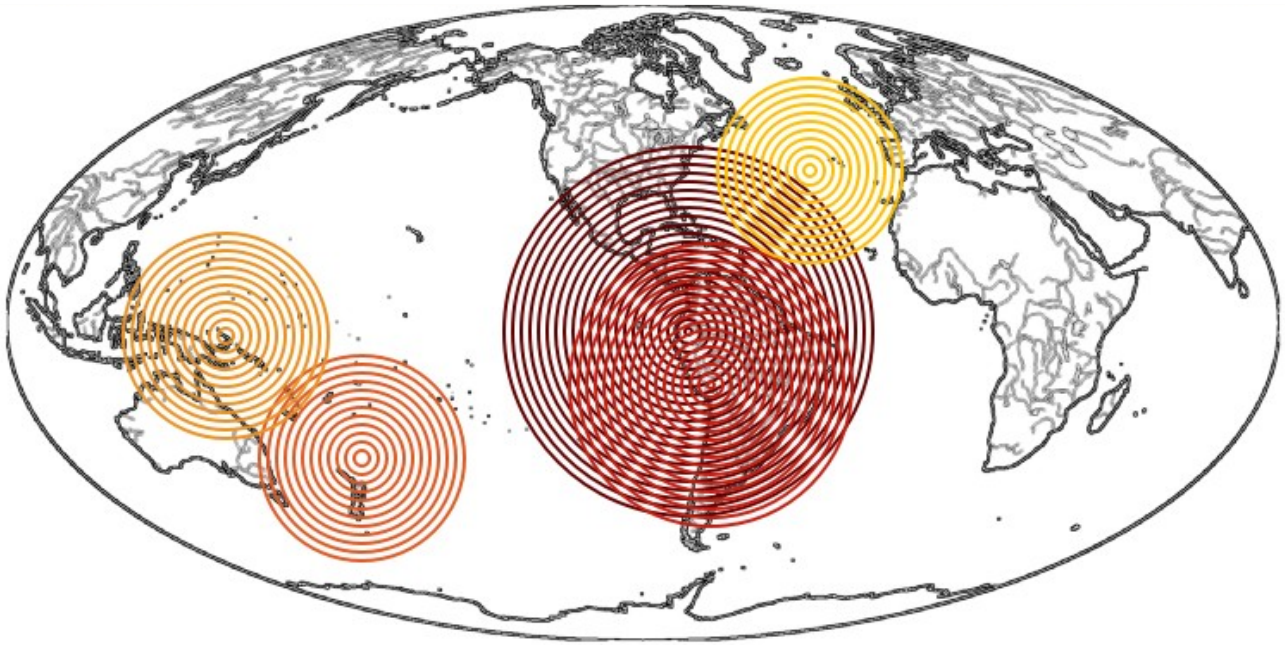
Assignment 3: Memoization, Recursive Optimization



Assignment 4: Recursive Backtracking



Assignment 5: Big-O, Sorting



This tool displays the strongest recent earthquakes reported by the US Geological Survey
You can use the controls on the side of the window to select the time interval you're interested in. This visualizer will show the 5 strongest earthquakes within that interval.

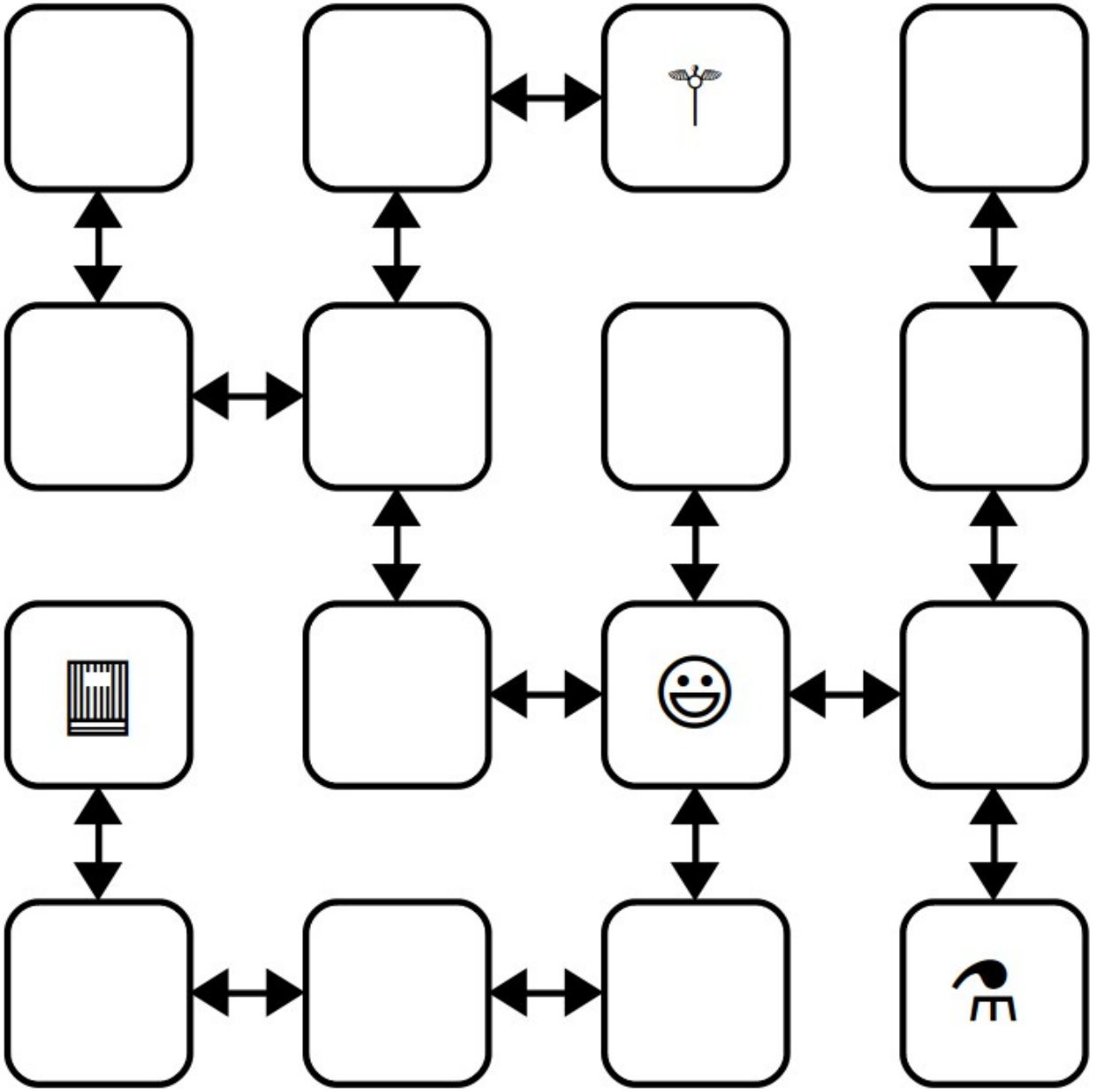
Remember that the earthquake magnitude scale is logarithmic. An earthquake that is on magnitude in strength higher than another releases around 32 times as much energy.

- Magnitude 7.5 115km ESE of Palora, Ecuador at 02:17:22 AM on Feb 22, 2019
- Magnitude 7 27km NNE of Azangaro, Peru at 12:50:41 AM on Mar 01, 2019
- Magnitude 6.4 116km SE of L'Esperance Rock, New Zealand at 07:46:14 AM on Mar 06, 2019
- Magnitude 6.4 49km NW of Namatanai, Papua New Guinea at 06:35:55 AM on Feb 17, 2019
- Magnitude 6.2 Northern Mid-Atlantic Ridge at 11:57:05 AM on Feb 14, 2019

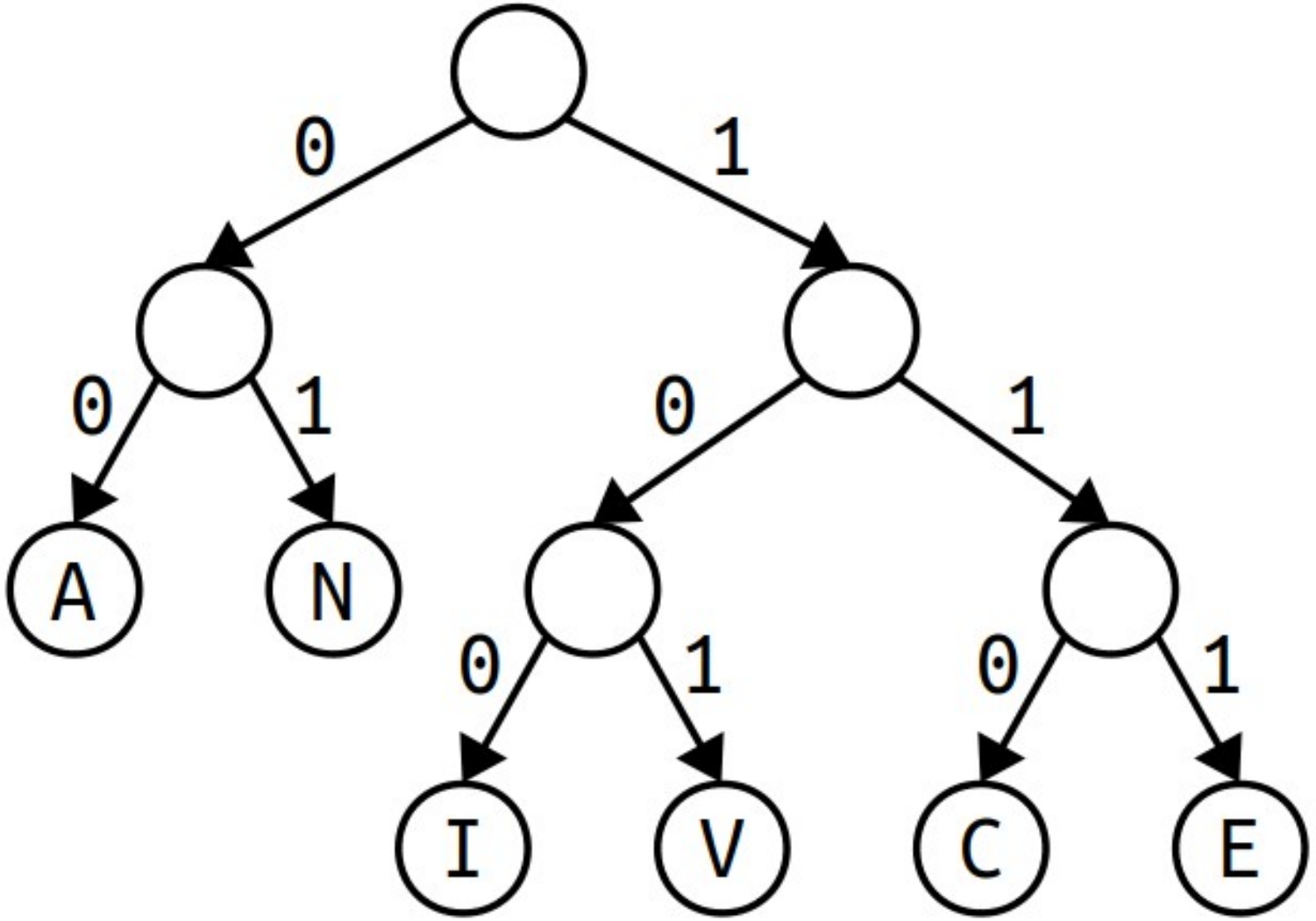
Assignment 6: Classes, Dynamic Arrays

		Chained Hashing	Linear Probing	Robin Hood Hashing
α = 0.5	Insert (success)	758.11ns	388.44ns	406.33ns
	Insert (failure)	424.51ns	247.08ns	262.46ns
	Lookup (success)	411.30ns	244.01ns	265.86ns
	Lookup (failure)	346.17ns	250.69ns	237.27ns
	Remove (success)	451.11ns	242.85ns	447.46ns
	Remove (failure)	285.53ns	251.65ns	240.45ns
α = 0.6	Insert (success)	745.39ns	390.01ns	410.35ns
	Insert (failure)	413.00ns	249.98ns	265.34ns
	Lookup (success)	412.50ns	245.00ns	261.22ns
	Lookup (failure)	349.92ns	255.58ns	236.88ns
	Remove (success)	448.89ns	243.58ns	441.84ns
	Remove (failure)	291.13ns	257.51ns	240.83ns
α = 0.7	Insert (success)	750.09ns	393.45ns	416.94ns
	Insert (failure)	415.35ns	251.90ns	271.68ns
	Lookup (success)	413.80ns	249.08ns	266.31ns
	Lookup (failure)	359.01ns	279.67ns	241.74ns
	Remove (success)	447.78ns	247.36ns	456.06ns
	Remove (failure)	296.00ns	280.64ns	245.12ns

Assignment 7: Hash Functions, Class Design



Assignment 8: Linked Structures



Assignment 9: Trees and Tree Searches

Computer science is more than just programming.

These skills will make you better at whatever you choose to do.

So what comes next?

What exactly is computer science?

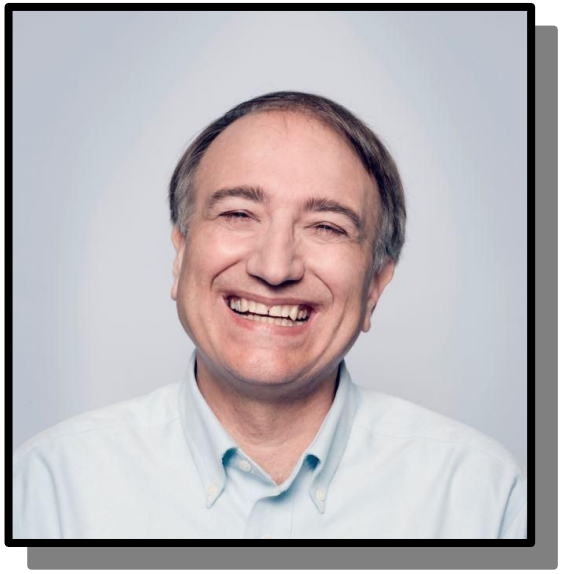
Fei-Fei Li
Artificial Intelligence

James Landay
Human/Computer Interaction

Chris Piech
Education, AI

Mary Wootters
Theoretical CS

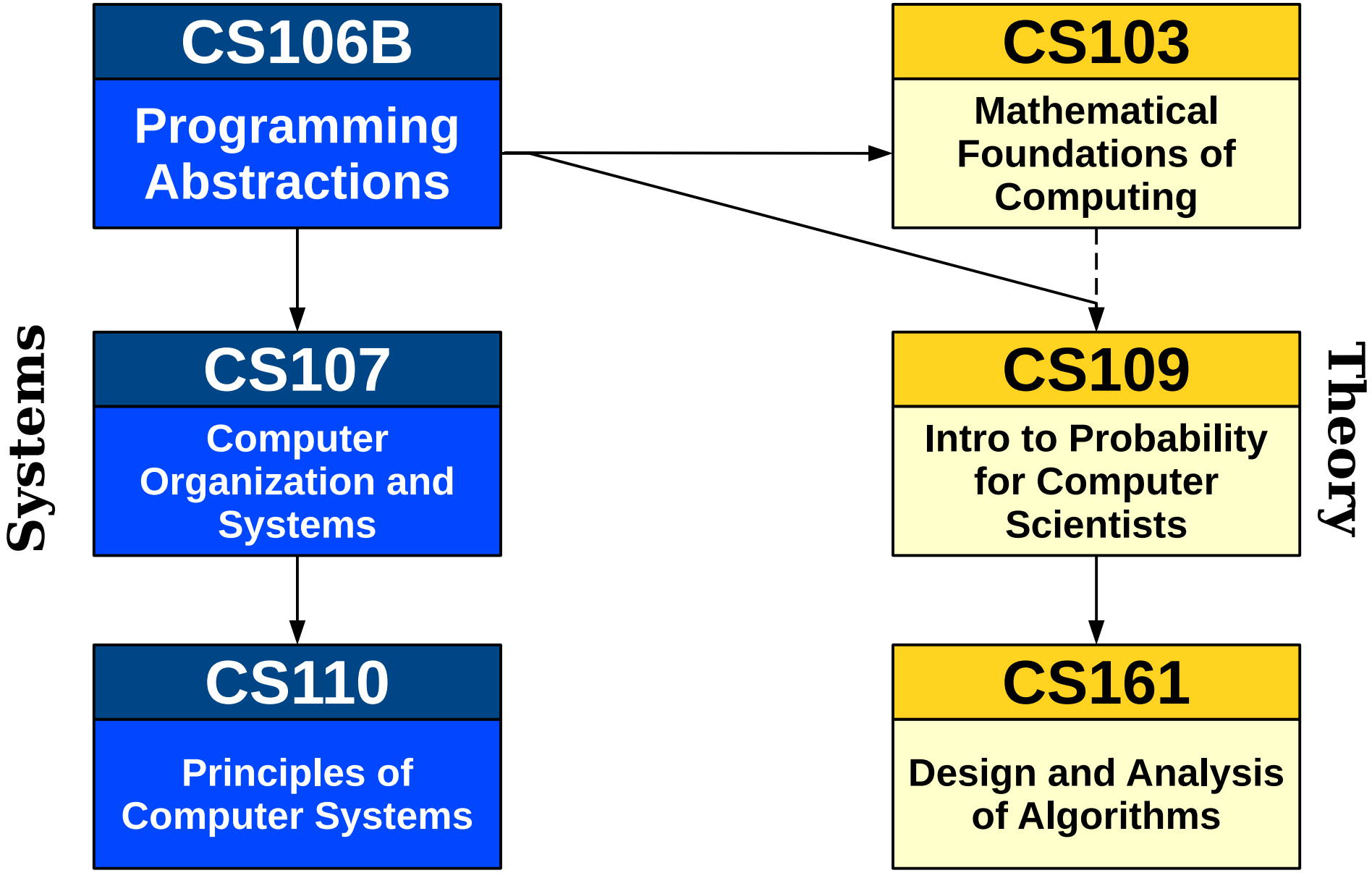
Jeannette Bohg
Robotics



Pat Hanrahan
Graphics, Systems

How do I learn more about it?

The CS Core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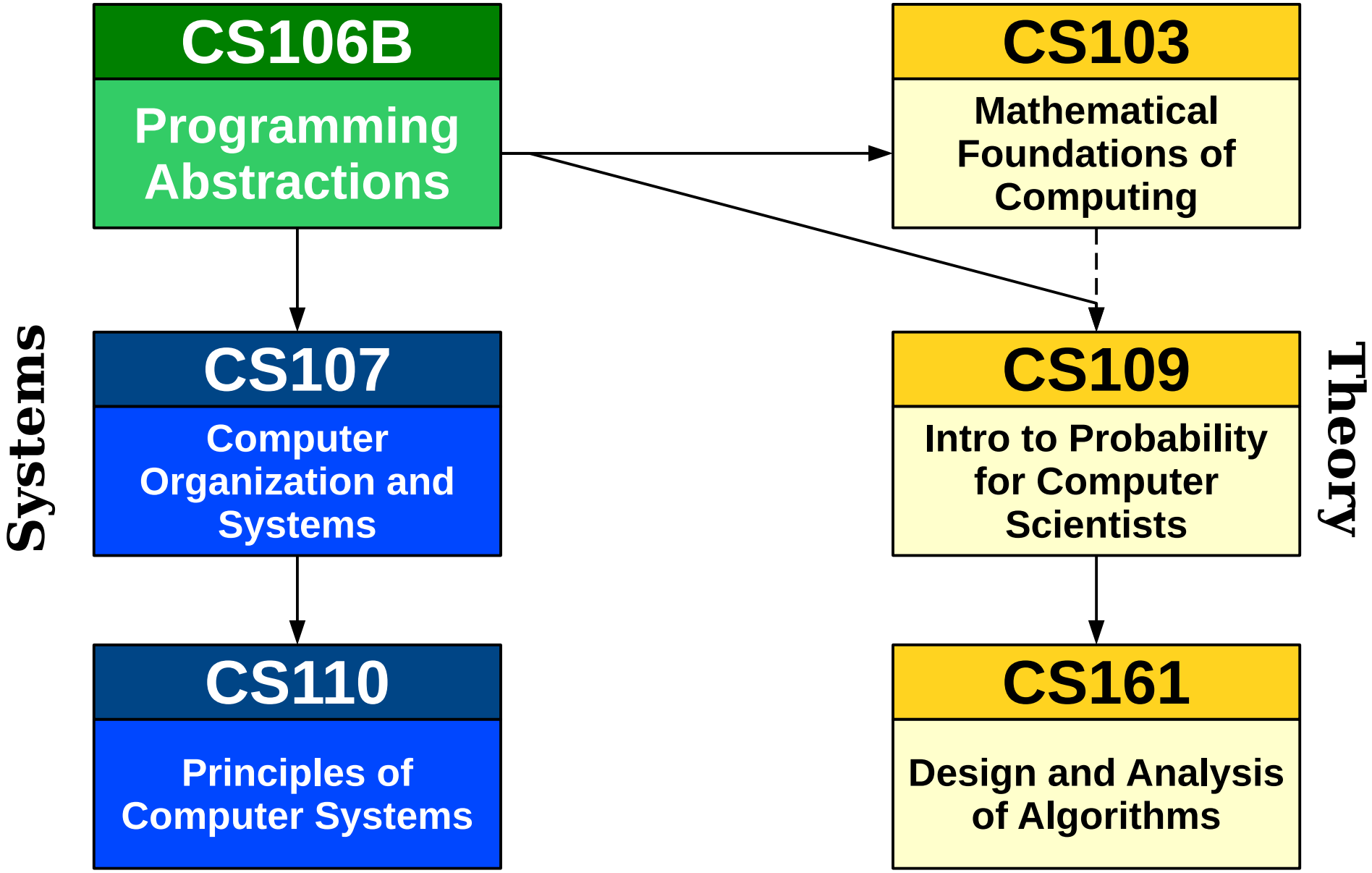
The CS Core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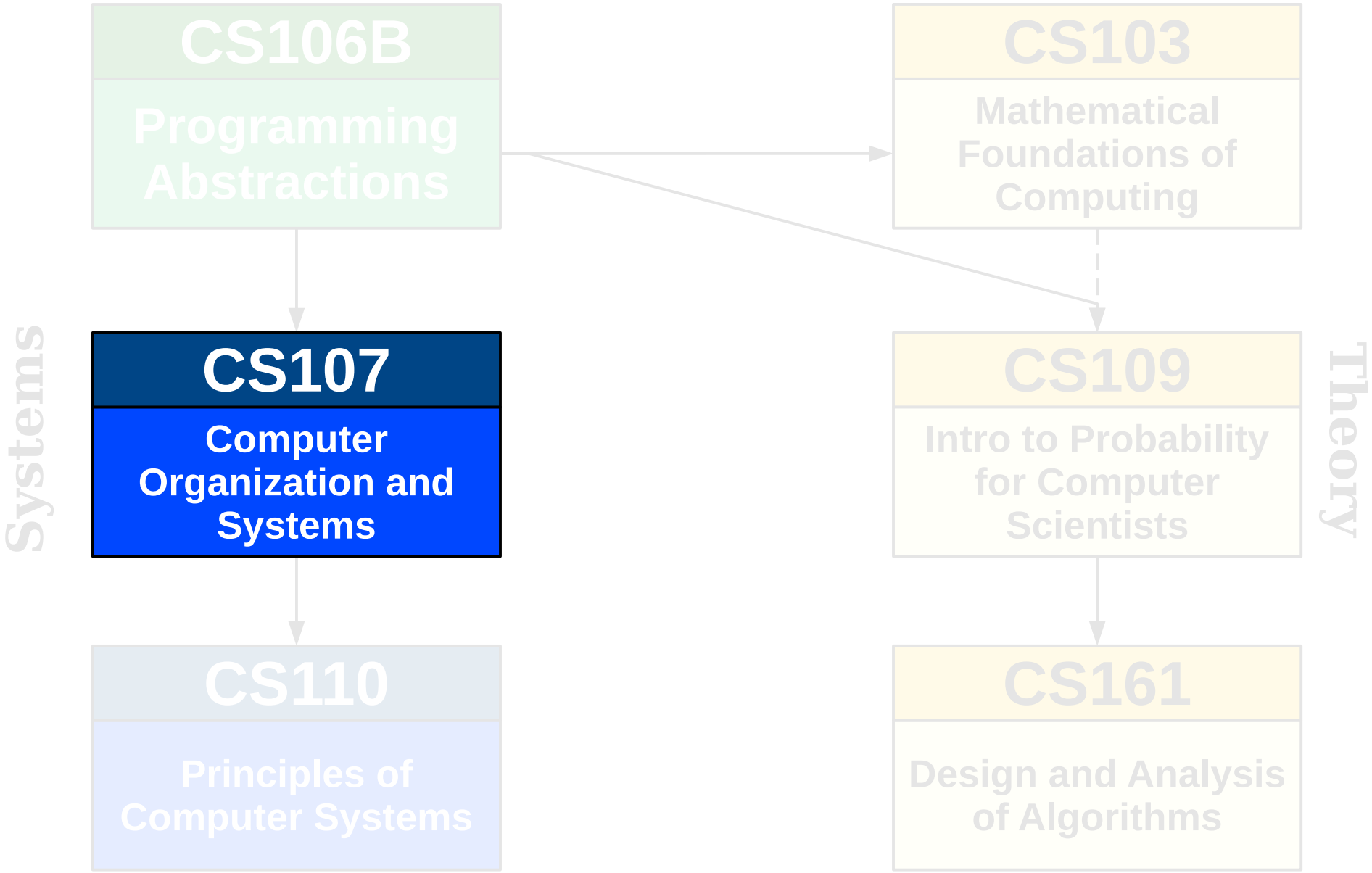
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CS107

Computer Organization and Systems

How does the computer work, at its most basic levels?

How do those low-level details lead to larger-scale phenomena?

What levels of abstraction lie beneath basic C++ concepts?

CS107E

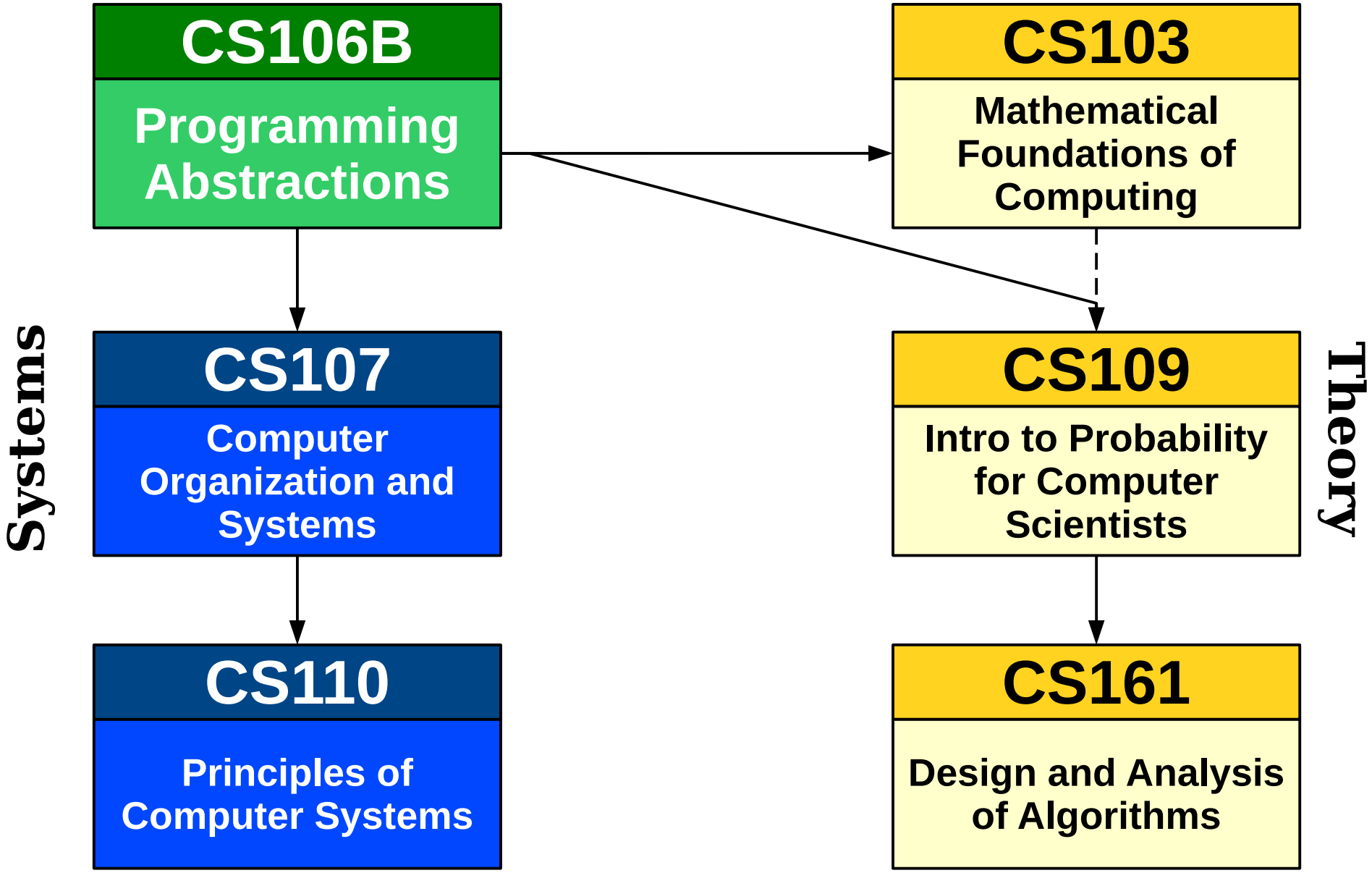
Computer Systems from the Ground Up

How can we use software to control hardware devices?

How do displays, keyboards, etc. get data into or out of the computer?

What's it like to build a computer system from scratch?

The CS Core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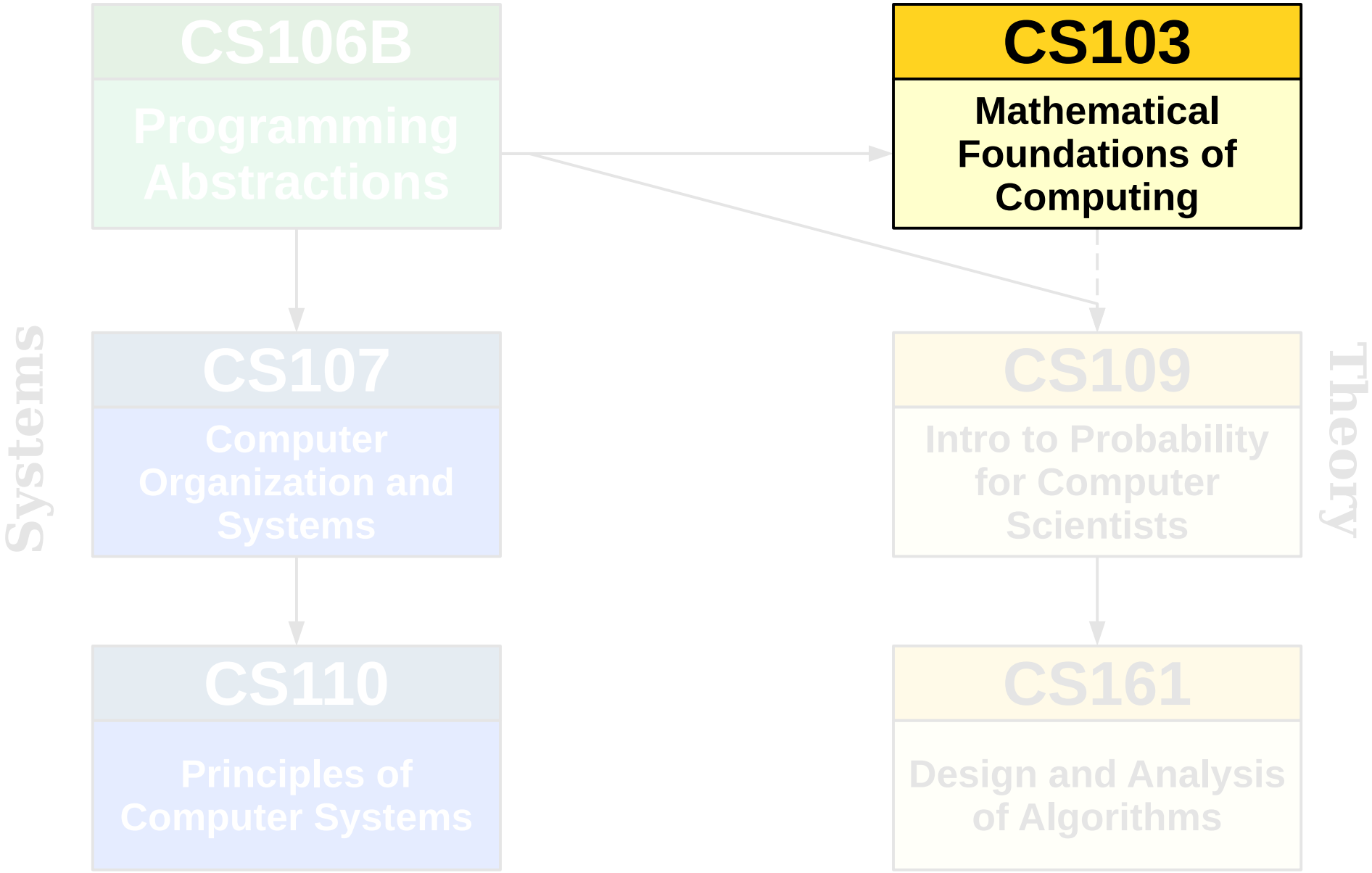
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CS103

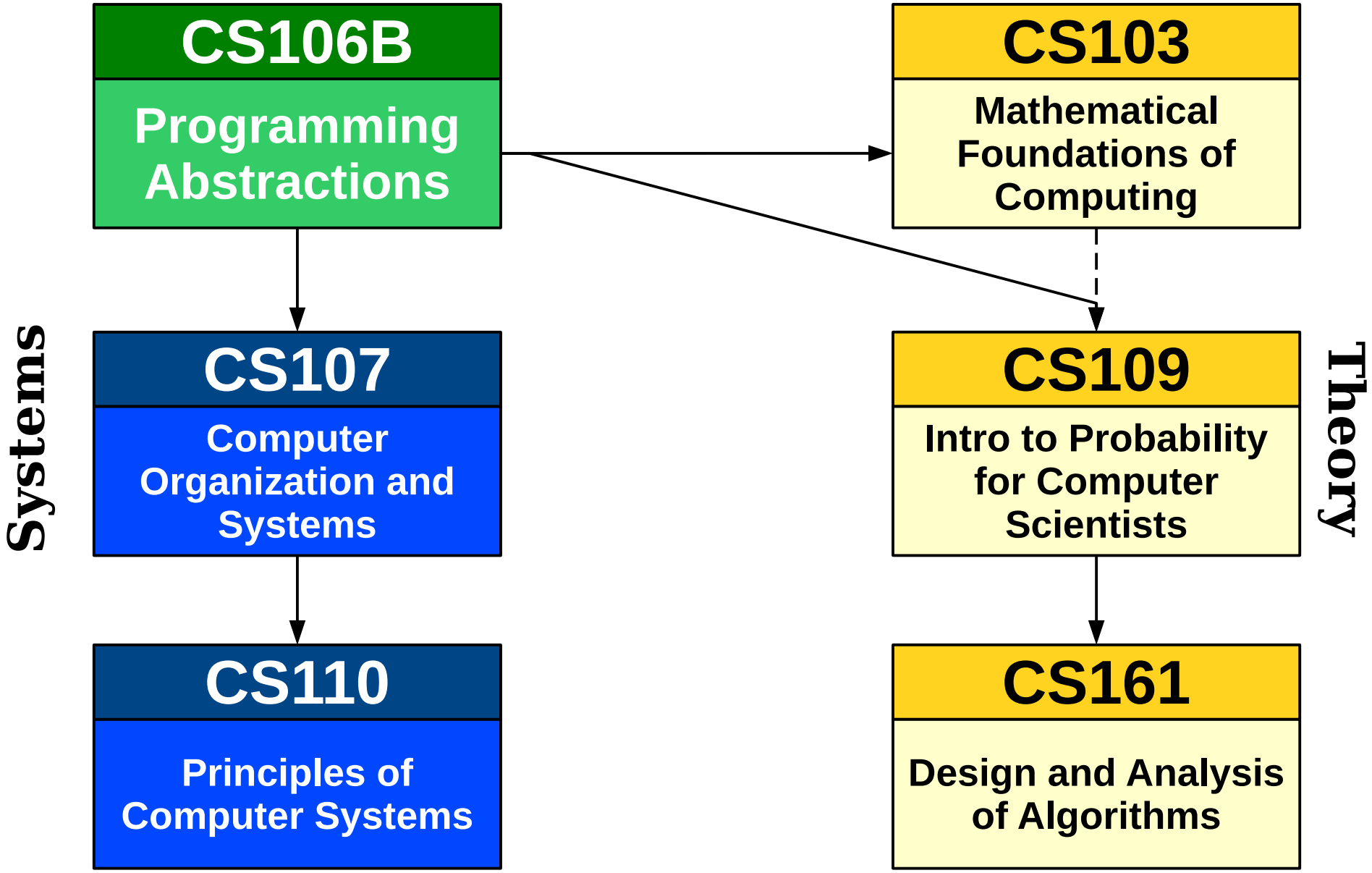
Mathematical Foundations of Computing

What mathematical tools can we use to analyze programs, processes, and graphs?

Why are some problems harder to solve than others?

Are there problems that cannot be solved by computers, and how would we know?

The CS Core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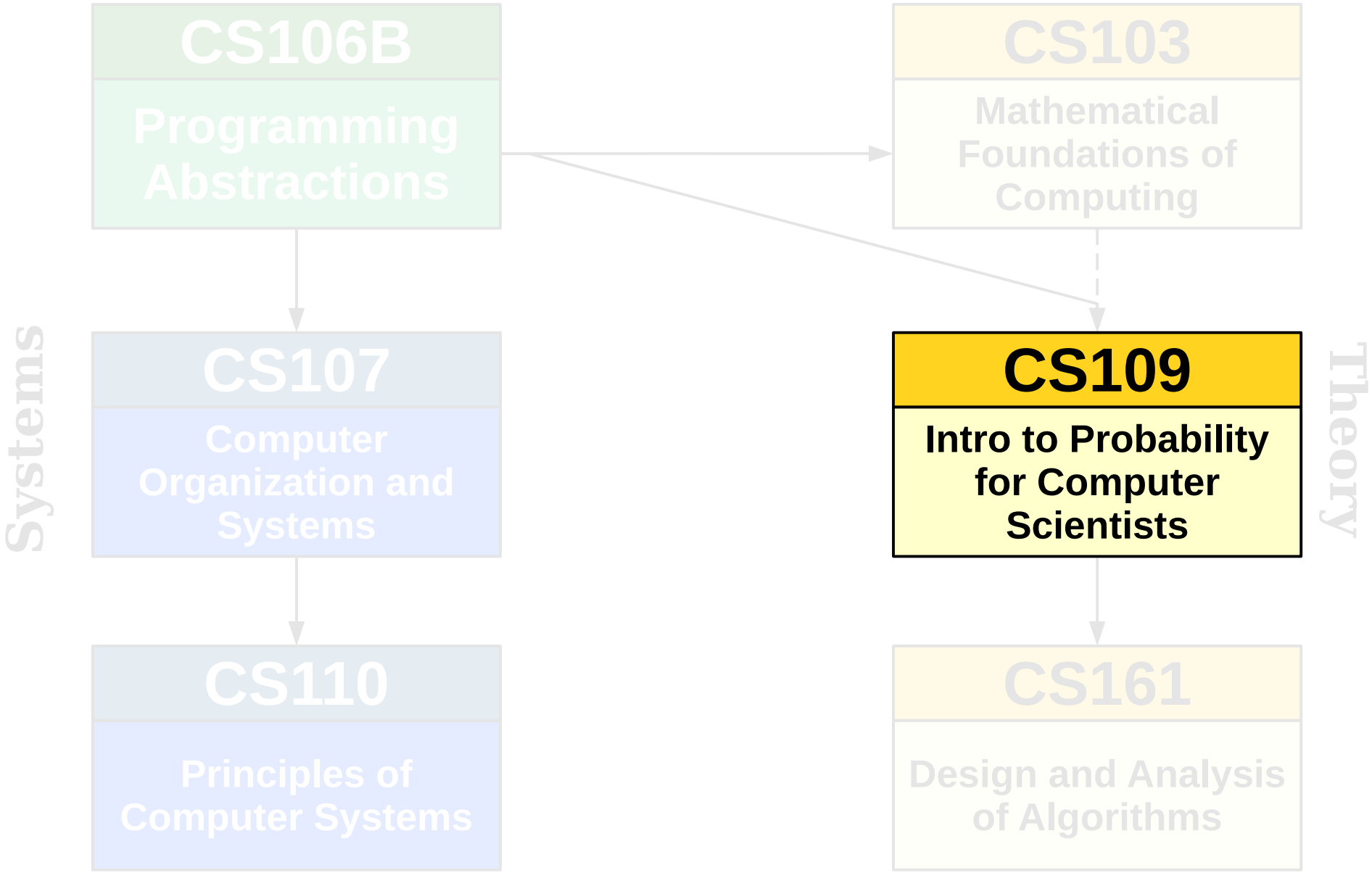
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CS109

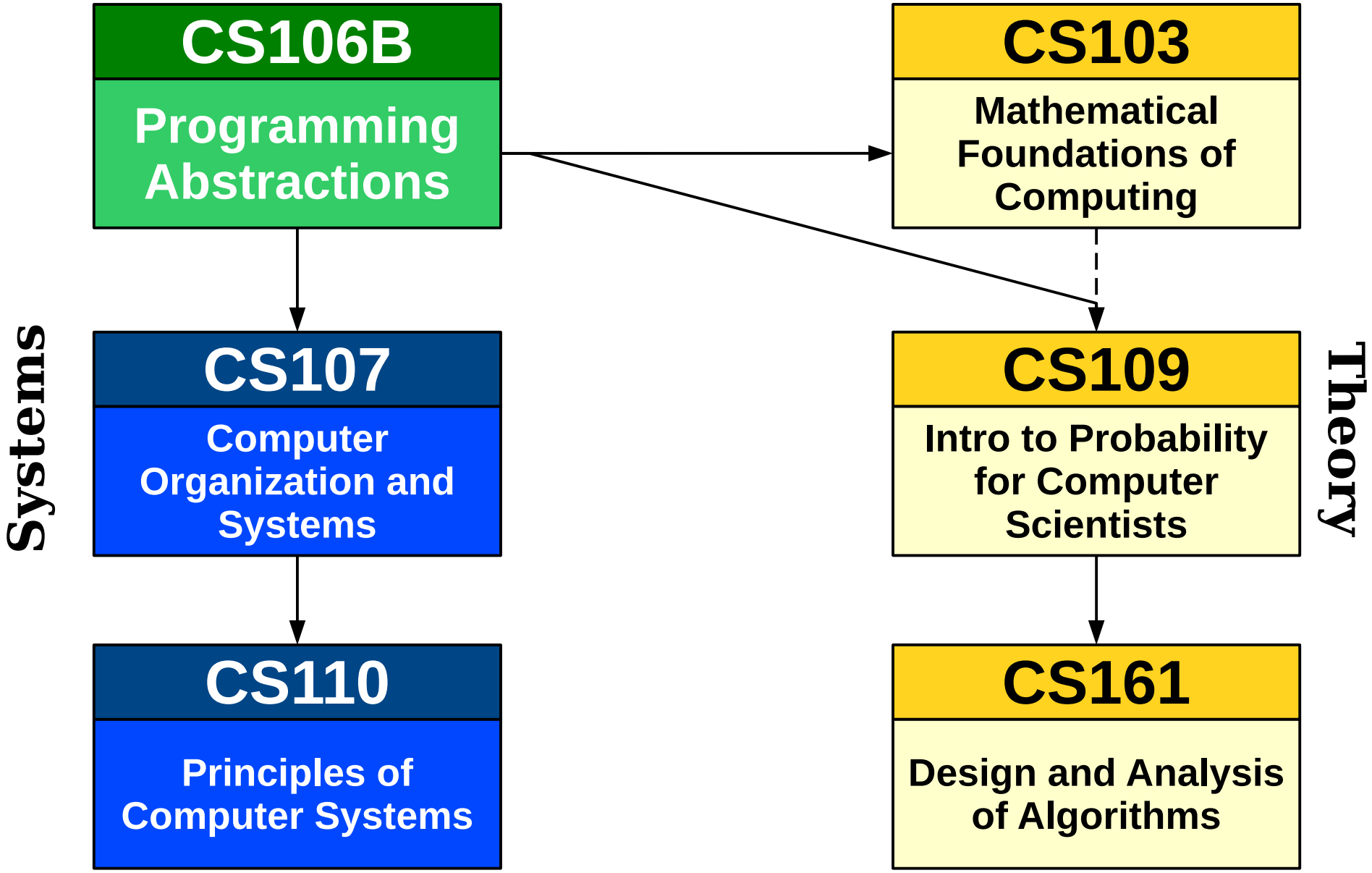
Probability for Computer Scientists

Why is a randomly-built binary search tree probably balanced?

How do we use computers to make sense of large data sets?

What is machine learning, and how do machines learn?

The CS Core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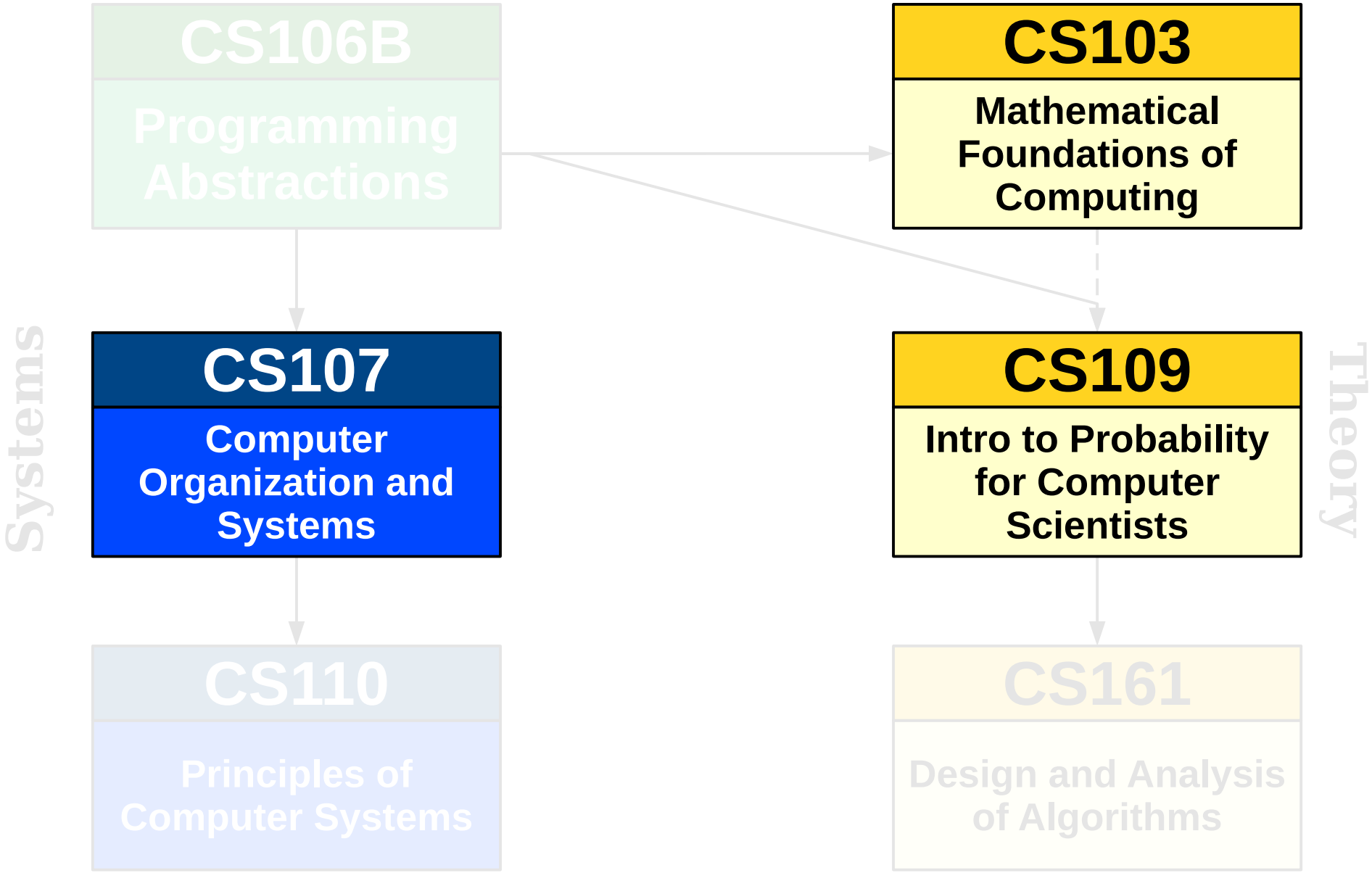
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Next Steps in CS

- It's reasonable to take one of CS107, CS103, or CS109 as a next CS class. You'll put in a good amount of work and learn a ton in the process.
- ***Do not feel pressured to do everything at once***. Taking two of these classes concurrently is a significant amount of work, and it isn't expected of you.
- Want some more guidance? Come talk to me after class!

Want to explore a bit?

CS5xx

(e.g. CS547, CS520, CS522, CS523, etc.)

- Any CS class of the form CS5*xx* is a seminar course.
- Frequently (not always), it's "show up, listen to interesting people speak, and take away what you will."
- These can be great ways to see what different fields are like, and the speakers are often really inspiring.

CS300

Departmental Lecture Series

- CS300 is a course where CS professors present about their research work.
- It was originally intended for PhD students; it’s now open to everyone.
- Only offered fall quarter; highly recommended if you want to learn more about what’s out there.

CS106E

Practical Exploration of Computing

- Broad survey of computing topics, including
  - how the internet works,
  - computer security,
  - how operating systems work,
  - bits and bytes, and
  - web programming.
- Great course if you're interested in working in the software industry in a non-technical capacity.

Want to learn specific technologies?

CS193x

(e.g. CS193A, CS193Q, etc.)

- Any class of the form CS193*x* is an introduction to a particular language or technology. For example:
  - CS193A: Android Programming
  - CS193C: Client-Side Web Technologies
  - CS193I: iOS Programming
  - CS193P: iPhone and iPad Programming
  - CS193Q: Accelerated Intro to Python
- Great for learning specific tools.

CS106L

Standard C++ Programming Lab

- Explore what C++ programming looks like outside of CS106B.
- Get exposure to the standard libraries and some really, really cool techniques beyond what we saw here.
- Excellent next step if you'd like to work in C++ going forward.

Want to dive deeper?

CS182

Ethics, Public Policy, and Technological Change

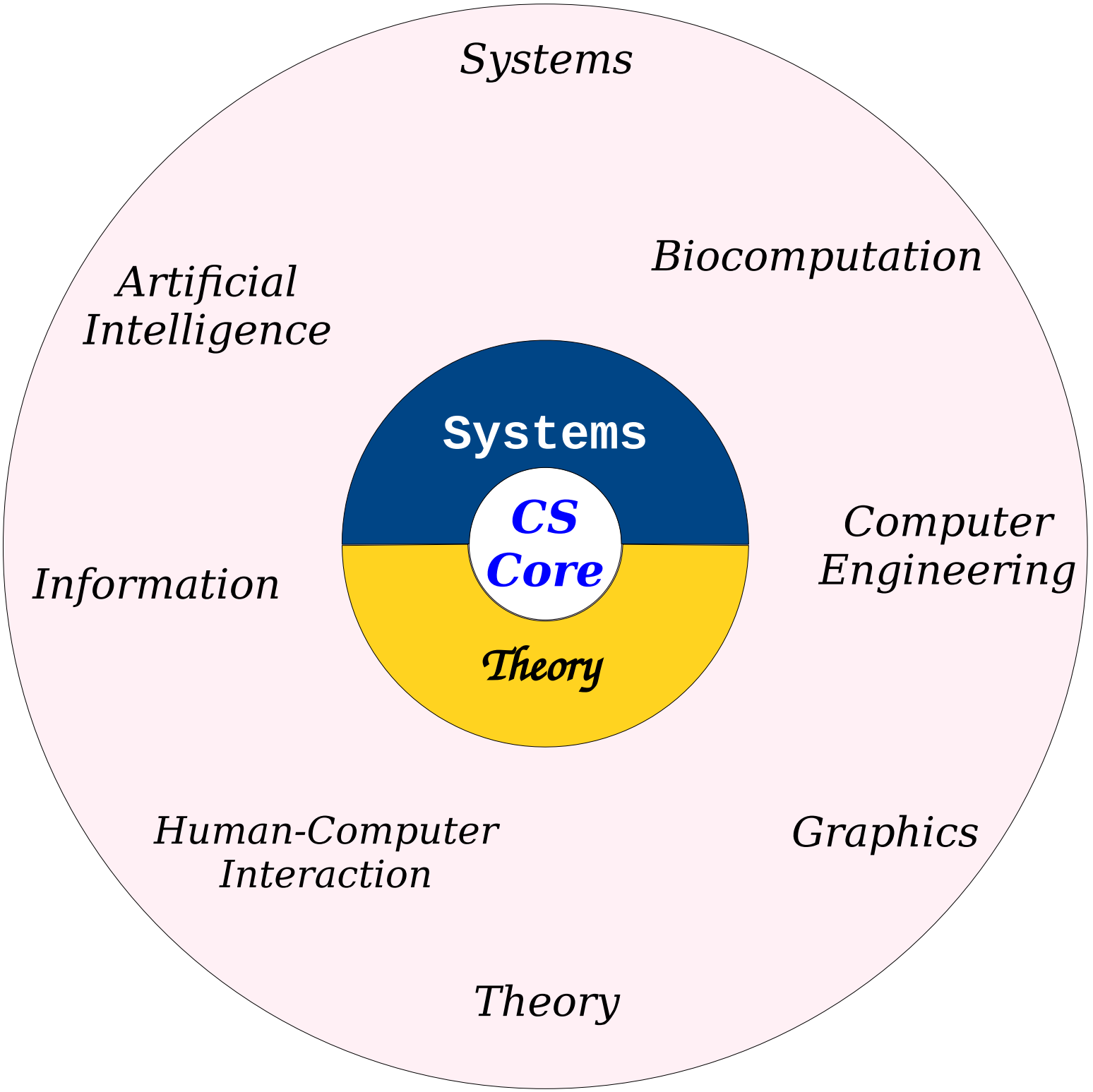
- What values does our technology reflect?
- How can we make sense of contemporary political and social debates over technology?
- What are the historical precedents for what we're seeing play out now?
- ***This class is truly fantastic. Please take it!***

CS147

Intro to Human-Computer Interaction

- How does design thinking apply in computer science?
- How do you prototype, evaluate, and refine a new piece of software?
- Prerequisite: CS106B! √

The CS Major


Systems
Biocomputation
Artificial Intelligence
Systems
CS Core
Theory
Computer Engineering
Information
Human-Computer Interaction
Graphics
Theory

Thinking about CS?

- Good reasons to think about doing CS:
  - I like the courses and what I’m doing in them.
  - I like the people I’m working with.
  - I like the impact of what I’m doing – or I want to steer how technology is developed and used in the world.
- Bad reasons to think about not doing CS:
  - I really enjoy this, but other people are better coders than me.
  - I’m learning a lot, but other people have been doing this longer than me and there’s no way for me to catch up.
  - I like the classes I’m taking, but the field is so big and I have no idea which area to focus in.
  - I don’t know what I’m going to be doing many years down the line, and I don’t want to be pigeonholed into just a tech person.

The CS Major

- A common timetable:
  - Aim to complete *most* of the core by the end of your sophomore year (probably CS106B, CS103, CS107, CS109, and one of CS110 and CS161).
  - Explore different tracks in your junior year and see which one you like the most.
  - Spend your senior year completing it.
- It’s okay if you start late!
  - The latest time you can *comfortably* start a CS major would be to take CS106A in winter quarter of sophomore year.
  - And the coterm is always an option!

For more information, visit

https://csmajor.stanford.edu/

The CS Coterm

What's the Coterm?

- It's a ***coterminal master's degree***.
- Work concurrently on your BS (in any subject) and your MS (in computer science).
- Designed with two populations in mind:
  - Give existing CS majors access to more depth and breadth of knowledge.
  - Give non-CS majors a chance to explore CS and emerge with a thorough command of the material.
- All Stanford undergrads are welcome to apply. This is intentional, and the door is open to all comers!

What’s the Coterm Like?

- The MS is 45 units, including the CS core (renamed the “foundations requirement”), breadth, depth, and electives.
- Expect to take three CS classes per quarter once you’re at “grad status.”
- TA (teaching) and RA (research) positions are available to offset tuition.
  - Full-time (“50%”) TA/RA positions offset tuition and provide a stipend.
  - Part-time (“25%”) TA/RA positions offset some tuition and provides a (smaller) stipend.
- With a 50% TA/RA position, you’re limited to 10 units/quarter. But that’s probably a good idea anyway.

Why Coterm?

- TA and RA positions are available to offset the cost.
  - Some of my best TAs did their undergrad in comparative literature, anthropology, and physics.
  - This is a great way to deepen your understanding of the material.
- Thinking about applying?
  - ***Take enough CS classes to establish a track record***.
    - CS106B on its own is probably not sufficient. Completing most of the CS core probably is.
  - ***Maintain a solid CS GPA***.
    - You don't need a 4.0 in your CS classes. You should aim to do well and make sure you're enjoying what you're doing.
- The department loves having coterms around. We don't have a quota, and (empirically, based on no insider knowledge) the application process is designed to accept as many qualified people as possible.

For more information, visit

https://cs.stanford.edu/admissions/current-stanford-students/coterminal-program

The CS Minor

What's the CS Minor?

- Five classes in CS: take CS103, CS107, CS109, plus two other depth classes.
- Nice option if you want to keep exploring CS while pursuing another major.
- For more information, visit

https://cs.stanford.edu/degrees/ug/Minor.shtml

Outside Stanford

Learning More

- Some cool directions to explore:
  - ***Specific technologies***. You already know how to program. You just need to learn new technologies, frameworks, etc.
  - ***Algorithms***. Learn more about what problems we know how to solve.
  - ***Software engineering***. Crafting big software systems is an art.
  - ***Machine learning***. If no new ML discoveries were made in the next ten years, we'd still see a huge impact.

How to Explore Them

- Online courses through Coursera, Udacity, edX, etc. are fantastic ways to learn new concepts.
  - Andrew Ng's machine learning course, Fei Fei Li's computer vision course, Tim Roughgarden's algorithms course, and Jennifer Widom's databases courses are legendary.
- Learning by doing is the best way to pick up new languages and frameworks.
  - Find a good tutorial (ask around), plan to make a bunch of mistakes, and have fun!
- Know where to ask for help.
  - Online resources like Stack Overflow can provide help (if you know how to ask questions well; that can take some practice!)

Some Words of Thanks

Who's Here Today?

- Aero/Astro
- African / Afro-American Studies
- Bioengineering
- Biology
- Business
- Chemical Engineering
- Chemistry
- Civil and Environmental Engineering
- Classics
- Computer Science
- Creative Writing
- Earth Systems
- Economics
- Education
- Electrical Engineering
- Energy Resource Engineering
- English
- Environmental Systems Engineering
- Environment and Resources
- Ethics in Society
- Geophysics
- Human Biology
- Immunology
- Individually-Designed
- International Policy
- International Relations
- Law
- Linguistics
- Management Science and Engineering
- Materials Science and Engineering
- Mathematical and Computational Science
- Mathematics
- Mechanical Engineering
- Music
- Physics
- Psychology
- Public Policy
- Science, Technology, and Society
- Sociology
- Symbolic Systems
- Theater and Performing Studies
- ***Undeclared!***

My Email Address

htiek@cs.stanford.edu

You now have a wide array of tools you can use to solve a huge number of problems.

You have the skills to compare and contrast those solutions.

You have expressive mental models for teasing apart those problems.

My Questions to You:

What problems will you choose to solve?
Why do those problems matter to you?
And how are you going to solve them?